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Factors Considered in the Development of Curricular Content in Engineering Technology for Diverse Audiences


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Abstract

Supply chains which handle and process bulk materials such as food ingredients and food stuffs have unique needs and challenges. Bulk material supply chains are characterized by the aggregation of large, homogeneous lots of product intended for a wide spectrum of end uses. Transportation and storage functions are also completed within a large-scale system, which add complexity to the management of these types of supply chains (Thakur & Hurburgh, 2009). Uncertainty and risk management are especially challenging.

The systems approach of engineering technology offers strategies for managing operations, risk and uncertainty in bulk materials supply chains. Furthermore, engineering technology graduates often possess the necessary disciplinary background and skills to potentially assume leadership roles within the bulk materials production system. Yet, the preparation of technical professionals remains largely unfilled in both higher education and in workplace training programs. This paper will discuss the challenges and needs of process industry supply chains, potential engineering technology solutions, and outline the strategies used to define core learning competencies for curricular and training programs intended for several diverse groups of learners. Implications for the field of engineering technology will conclude the paper.

Disciplines

Agriculture | Bioresource and Agricultural Engineering | Engineering Education | Operational Research | Operations and Supply Chain Management | Systems Engineering

Comments

The paper, "Factors Considered in the Development of Curricular Content in Engineering Technology for Diverse Audiences" (Gretchen A. Mosher and Chad M. Laux), as published in the Proceedings of the ATMAE 2012 Conference (2012 ATMAE Annual Conference, Nashville, TN, November 14–17, 2013) is a copyrighted publication of ATMAE, the Association of Technology, Management, and Applied Engineering, 1390 Eisenhower Place, Ann Arbor, MI 48108. This paper has been republished with the authorization of ATMAE, and may be accessed directly from the ATMAE website at <http://atmae.org/index.php/conference-20#pastconfpaper>.

Administration

Factors Considered in the Development of Curricular Content in Engineering Technology for Diverse Audiences

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Introduction

Supply chains which handle and process bulk materials such as food ingredients and food stuffs have unique needs and challenges. Bulk material supply chains are characterized by the aggregation of large, homogeneous lots of product intended for a wide spectrum of end uses. Transportation and storage functions are also completed within a large-scale system, which add complexity to the management of these types of supply chains (Thakur & Hurburgh, 2009). Uncertainty and risk management are especially challenging.

The systems approach of engineering technology offers strategies for managing operations, risk and uncertainty in bulk materials supply chains. Furthermore, engineering technology graduates often possess the necessary disciplinary background and skills to potentially assume leadership roles within the bulk materials production system. Yet, the preparation of technical professionals remains largely unfilled in both higher education and in workplace training programs. This paper will discuss the challenges and needs of process industry supply chains, potential engineering technology solutions, and outline the strategies used to define core learning competencies for curricular and training programs intended for several diverse groups of learners. Implications for the field of engineering technology will conclude the paper.

Challenges and Needs of Process Supply Chains

Managing bulk materials from production to consumption is a challenging task. Bulk supply chains are not characterized by the process controls and verification of quality standards which are typical to other industries (Hurburgh & Lawrence, 2003). Normally, bulk material supply chains handle a wide variety of products which have multiple transportation routes, making it difficult to design a standardized system to address system-wide hazards of safety and security (Thakur & Hurburgh, 2009). Furthermore, the wide variety of end uses does not lend itself well to a few universal solutions to manage all of the products within the entire supply chain. Rather, solutions must be developed on a case-by-case basis.

A second challenge of bulk material supply chains involve storage and inventory management. Storage units for bulk materials may contain product from many sources. Once the products are combined (as is the traditional practice for bulk material supply chains), lot identity is nearly impossible to re-establish (Harris, 2009; Thakur & Hurburgh, 2009). Under the blending scenario typical to bulk material handling and process, in the event of a bulk material recall, no feasible way exists to isolate contaminated product. Because the adulterated product cannot be separated physically, all of the product with a potential of contamination must be recalled (Thakur & Hurburgh, 2009; Thakur et al., 2009), leading to a financial loss in many cases. These scenarios present risk and uncertainty to businesses that handle and process bulk materials.

Finally, the stability of bulk biological products may also present a challenge for supply chain managers. Bourne (2004) suggests that the loss of products which are not stored and managed appropriately result in a loss of nutrients and profit. Although technological tools can be applied to both increase the shelf life and to convert perishable products into more shelf products, the potential loss of money and profit are a constant risk in bulk material supply chains (Bourne, 2004).

Additionally, when contamination or adulteration incidents occur, the bulk material supply chain is not well equipped to identify or measure low concentration consumer safety events. Threats occurring to consumer safety from bulk materials are often not large in their initial scope, but the magnitude of the incident may increase rapidly, resulting in a large financial loss for the firm or firms involved. Even with minor incidents, the unique characteristics of the bulk material supply chain make it difficult to isolate and control hazards that do arise (Thakur et al., 2009).

Although prescriptive and control-point based interventions may play some role in a process-based supply chain systems, they cannot address the multi-tiered need for identification, quantification, control and management of bulk material safety and quality risks (Sperber, 2005; Anderson, 2009). A move away from prescriptive-based interventions in favor of a process and systems-based approach has shown promise in the ability to address bulk material and food safety risks (Thakur et al., 2009).

Engineering Technology Can Address Industry Needs

Bulk material supply chains have unique and multi-faceted needs. Foster's (2008) definition of the systems-based approach of quality management involves managing the interacting aspects of supply chains to enhance the performance of suppliers and customers. Laux (2007), Laux, Mosher and Hurburgh (2008), and Laux and Hurburgh (2010) demonstrated that quality management systems could play a positive role in managing process-based supply chains by improving inventory management and managing legislative requirements.

Thakur and Hurburgh (2009) agreed with these findings, and further concluded that a key component of improved performance among all participants in the supply chain is an enhanced system of information exchange, with a specific focus on linking units of output with explicit units of input. Bertolini, Bevilacqua, & Massini (2006) also proposed that successful supply chain systems for bulk materials must facilitate a rapid information exchange between participants. Creating a system conducive to quick information exchange involves the integration of several important factors. Engineering technology programs offer a systems approach for addressing several long-standing quality and safety issues in the bulk material supply chain (Laux & Hurburgh, 2010; Thakur et al., 2009). Process-based activities such as statistical process control, mathematical modeling, procedural and design protocols, and the multidisciplinary integration of theories in management and cost analysis are required components of an ATMAE accredited engineering technology degree program (ATMAE Accreditation Handbook, 2009, p 18). Furthermore, the multidisciplinary focus of engineering technology programs have the ability to produce professionals who are able to design, develop, measure, and evaluate multiple interacting systems. The ability to balance the management of quality with the management of risk allows engineering technology professionals to improve and optimize current bulk material supply chain processes and practices.

Specific to the field of engineering technology, Meier, Williams and Singley (2004) suggest that a systemic model of understanding and evaluation of the practice of supply chain management is needed for significant improvement in the field. Callahan, Amos, and Strong (2004) add that preparation of students to work in this area should expand to include greater coverage of quality-related issues such as capability analysis and statistical process control. A greater exposure to hands-on problem solving, an increase in context and product-specific experiences, and a better integration of statistical theory into a quality environment are proposed by Callahan and Strong (2004) to improve the undergraduate preparation in quality management and quality processes.

A 1999 study by Zagari and Hayes revealed that student perceptions align with faculty thoughts on engineering technology strengths and needed improvements. Those surveyed listed hands-on, practical problems as something they would like to see more of in technology programs. However, Zagari and Hayes (1999) also found that students were overall very pleased with the balance of technical and laboratory courses as well as the multidisciplinary focus of industrial technology programs.

The next section will briefly describe the approach used to develop core learning competencies for students entering the bulk material supply chain workforce. Bulk material supply chain workers come from a variety of educational levels. To ensure a broad representation of perspectives, the opinions of academic and industrial stakeholders were sought. The competencies discussed below are the result of these stakeholder round table discussions.

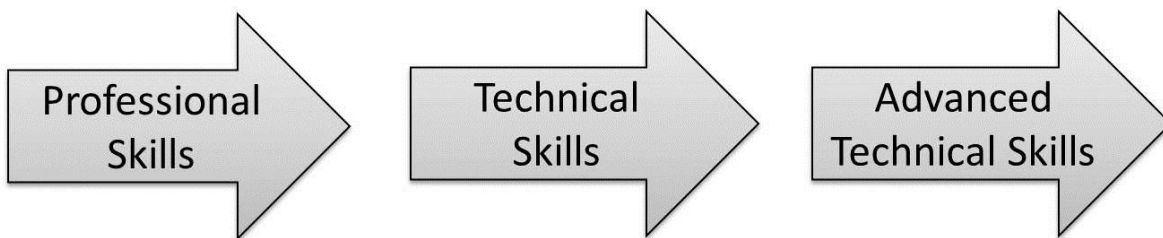
Core Learning Competencies for Engineering Technology Students

The Engineering Technology student today must have a broad based education; yet culminate in advanced and technical instruction to meet the needs of the bulk material, food, and food stuff industry. The pathway to a 4-year degree varies with the college student today arriving in a baccalaureate program through many means: direct from high school, as a returning adult upgrading or revising a career set, or coming through a two-year associate degree program (National Center for Educational Statistics, 2012). Adults already working in the industry may also be in need of re-training programs to better prepare them for challenges that did not exist when they started in their chosen occupation (Patel, 2010).

Core Competencies for College Students

Approximately 40 companies representing the bulk material, food, and foodstuff industry were brought together to help identify competencies for Engineering Technology graduates. At each round table session, the participants were charged with answering two questions:

- 1) What knowledge should the Engineering Technology graduate possess?
- 2) What skills should the Engineering Technology graduate be able to perform?



The initial response from industrial and academic stakeholders was that while the specific pedagogical process may differ by group of student, a stronger set of competencies could be created if the classification system was by skill area rather than by student group. The professional skills noted are not unique to bulk materials, food, or foodstuff, or even the technical level of a student. The first list of “professional skills” competencies broadly represents the knowledge and skills required for a student to engage in an occupation or career. The areas of “technical skills” and “advanced technical skills” are more unique to the field of engineering technology and the bulk materials supply chain. Figure 1 illustrates the pathway identified by the round table participants.

The technical skills and knowledge presented are the result of the types of stakeholders present. More specifically, different employers have different needs and their opinions on what workers should know may vary. Therefore, the competencies listed are not necessarily skills needed for every work environment. Nevertheless, the technical competencies represent the broad categorical set of knowledge and skills required for the 21st century STEM professional. These professionals will work in an industry sector that is open to the needs and desires of globalization so that they may tap into a competitive, skilled, and globally-minded workforce.

The “advanced technical” competencies represent the ultimate learning objective for the advanced, technical person working in this sector. Thematically, these areas are not mutually exclusive, nor should they be treated as such. In addition to the curriculum as a connector of these areas, one thing that the educator must also be mindful of is, regardless of the student level (Associates, Bachelors, or Adult), the student must be employable (Brumm, Hanneman, & Mickelson, 2006). Thus, the path to higher education for the technical student must contain relevant and technically advanced content, yet still prepare a well-rounded professional.

Competency-based education is increasingly being used in diverse learning environments (Boyatzis, 2008). Brumm, Mickelson, Steward, and Kaleita (2006) describe competency-based education as a focus on what students are expected to know or do by the time they complete the program, rather than simply measuring the completion of a specified sequence of learning modules. Competency-based learning requires the definition of learning objectives and then an alignment of the learning outcomes with the skills identified as important for potential employees. One key advantage to competency-based learning is its transparency. This means that all parties understand the learning goals and are given a clear map of how the learning will take place (Brumm et al., 2006). Measureable assessment and the opinion of external stakeholders are the major bases for evaluation of competency-based learning models. The competencies identified by the round table groups are shown in Table 1.

Table 1. Engineering Technology graduate competencies for the food and foodstuff industry

Professional Skills	Technical Skills	Advanced Technical Skills
<ul style="list-style-type: none"> • Passion for career • Common sense and maturity • Problem solving • Managerial, supervision, leadership, and people skills • Positive attitude and motivation • Business writing and communication (internal and external) • Foreign language skills • Respect for international colleagues • Human resources knowledge (organizational measurement) • Market differentiation • Project management • Business sense • Advancement mentality • Willingness to relocate • Willingness to get dirty, take non-office jobs 	<ul style="list-style-type: none"> • Automation • Fundamental computer skills (Excel, spreadsheet) • Knowledge of industry standards • Knowledge of basic statistics • Ability to handle biologically active products • Workplace safety knowledge • Bulk processing knowledge • Social aspects of food • Food, diet, medical, and health challenges of existing population 	<ul style="list-style-type: none"> • Advanced technology & electronics work skills • Knowledge of Biologics • Lean manufacturing knowledge and skills • Bioprocessing knowledge • Microbiology knowledge • CFR 21 standards knowledge • Process controls • Regulations/operating systems and standards • GFSI • ISO standards • Knowledge of OSHA, EPA, IDEM • Project analysis skills • Risk mitigation skills • HACCP knowledge • Hygienic design knowledge • Quality management systems knowledge • Quality auditing

Core Competencies for Adult Learners

The preparation of college students normally follows a formal curriculum process, but the preparation of adults for new or changing careers has a slightly different focus. Generally, it is assumed that adult learners have a different approach to learning than secondary and post-secondary students (Cranton, 2006). The typical adult learner tends to be more self-directed than college-aged students and learning may be more voluntary than is the case in other learner groups (Cranton, 2006). Adults commonly enjoy sharing their experiences in a practical discussion format, where useful, applicable and relevant information is presented (Cranton, 2006; Knowles, 1980). Additionally, using the past experiences of adults in the learning has proven to be a very effective way of engaging adult learners in the course content (Dollisso & Martin, 1999). For this reason, many opportunities for discussion, open-ended questions and reflection on past experience and behaviors were integrated into the learning modules designed for adult learners.

Three major components were used in the initial development and modification of adult student core learning competencies. The first means of evaluation were the existing needs of the bulk material supply chain system. Published literature provided the biggest portion of the information used to identify the needs of bulk material supply chain. Based on the literature reviewed, several needs emerged. These include: a systemic approach to identifying risks, an enhanced communication system linking all parts of the supply chain, and a cost effective method to encourage industry adoption (Foster, 2006; Laux & Hurburgh, 2010; Thakur & Hurburgh, 2009; Thakur et al., 2009).

The second component used in the development of core learning competencies for adult students was the review and critique of competencies and course content by a panel of industry experts. Kingman et al. (2005) have found expert panels to be an effective and cost-effective tool for defining curricular content in several work environments. The use of expert groups has been found to promote problem identification, the formulation of ideas, and the development of strategies (Kingman et al., 2005). All are positive actions in the development of a relevant and updated curriculum in bulk material supply chain system, particularly for adult learners.

The final piece of feedback was generated by students who participated in the learning courses and workshops, which have been offered since the spring of 2010. The student feedback was integrated into future course and workshop offerings to better align the course and workshop offerings with the needs of the participants. The effectiveness of the curriculum was

evaluated using Kirkpatrick and Kirkpatrick's 4-Level Evaluation System (Kirkpatrick & Kirkpatrick, 2007). The full evaluation of the curriculum delivered for adult learners in 2010 and modifications made to the 2011 as the result of student evaluations are discussed in greater detail by Mosher, Freeman, & Hurburgh (2011).

Implications for Engineering Technology

The field of engineering technology has the potential to address several long-term needs of the bulk material supply chain. Based on the needs and learning competencies identified by academic and industrial professionals in the field of process-based supply chains and engineering technology, the field is poised to assume a leadership role in preparing professionals to take on the challenges of the 21st century global bulk material, food, and foodstuff system.

With the use of tools such as statistical process control, quality management, and information systems management, engineering technology professionals can begin to address the systemic challenges of the bulk material supply chain, from a global, national, and regional perspective. Although this direction represents a new role for engineering technology graduates, the field is well-positioned to move in this direction.

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